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Forest Pest Management Report

R-3 85-3

BIOLOGICAL EVALUATION
Western Spruce Budworm

Carson National Forest
New Mexico

December 1984

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USDA Forest Service, Southwestern Region
State and Private Forestry
Forest Pest Management
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INTRODUCTION

The western spruce budworm (WSBW), Choristoneura occidentalis Free., is currently at outbreak levels throughout most of the Douglas-fir, true fir, and spruce host type on the Carson National Forest (CNF). WSBW defoliation was first visibly[1] detected on the Taos and Questa entomological units in 1975 and 1976, respectively. New areas of budworm defoliation were next aerially observed on the Tres Piedras and El Rito[2] entomological units in 1980 and on the Canjilon Ranger District and Jicarilla Indian Reservation in 1982. In 1984, approximately 238,725 acres of host type were observed defoliated on the CNF, Taos Pueblo Indian lands, and adjacent lands of mixed ownerships. Total acres defoliated on these ownerships from 1976 through 1983 are summarized by entomological unit and level of intensity in table 1.

Also in 1984, egg mass samples were collected from the Taos, Questa, Tres Piedras, and El Rito entomological units. These data are summarized in this evaluation. Management alternatives and recommendations are also presented.

TECHNICAL INFORMATION

Insect. Western spruce budworm, Choristoneura occidentalis Freeman

Hosts. Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco
White fir, Abies concolor (Gord. & Glend.) Lindl.
Subalpine fir, Abies lasiocarpa (Hook.) Nutt.
Blue spruce, Picea pungens Engelm.
Engelmann spruce, Picea engelmannii Parry

Life History. The western spruce budworm completes one generation each year (Furniss and Carolin 1977).

Stage	Time	Location on host
Egg	August	On needles
Small larvae	Overwinter	In hibernaculum (silken cocoons) on branches and trunk
Larger larvae	June	On buds, strobile, and foliage
Pupae	July	On foliage
Adults	August	In flight

[1] Visible defoliation based on aerial detection survey.
[2] Formerly included as part of the Tres Piedras entomological unit from 1980 through 1981.

Evidence of Infestation

1. Presence of partially eaten foliage.

2. Mature larvae feeding on current year's needles.

3. Current year's shoots webbed together by larvae.

4. Defoliation most evident in upper crowns of trees.

5. Trees dying from the top downward after several years of heavy defoliation.

Extent of Infestation in 1984. Defoliation, as detected from aerial sketch-map surveys, increased on the CNF and adjoining lands from 100,700 acres in 1983 to 238,725 acres in 1984. Severity of defoliation was categorized as: Light, 43,375 acres; moderate, 100,075 acres; and heavy, 95,275 acres. In addition, 9,600 acres of apparent mortality were detected. Acres of defoliation and/or mortality by separate ownerships are as follows:

	Defoliation				
	Light	Moderate	Heavy	Total	Apparent mortality
Carson NF	34,200	84,625	81,575	200,400	7,350
Taos Pueblo IR	8,600	12,325	8,425	29,350	1,700
Other adjoining land	575	3,125	5,275	8,975	550

Extent of aerially observed defoliation in 1984 is summarized by the following entomological units:

Questa. Defoliation increased fivefold on the Questa entomological unit from 9,825 acres in 1983 to 52,700 acres in 1984. Most defoliation on this unit was categorized as moderate or heavy (figure 1), and occurred throughout much of the mixed conifer forest type in Cabresto, Red River, and Hondo Canyons, and along the lower west-facing slope of the Sangre de Cristo Mountains from Latir Creek south to Arroyo Seco. Areas of apparent mortality, totaling 7,150 acres, were also observed in Cabresto, Red River, and Hondo Canyons.

Valle Vidal. A total of 10,300 acres of defoliation was detected on the Valle Vidal entomological unit in 1984. This was the first reported defoliation on this unit in recent years. Areas of defoliation were categorized as light or moderate and occurred in the Comanche, Vigil, and Middle Pond Creek drainages (figure 2).

Taos. Defoliation was evident throughout the Taos entomological unit in 1984, including previously unrecorded defoliation in the Rio de la Olla and Rio Grande del Rancho drainages (figure 3). Total acres of defoliation increased from 21,550 in 1983 to 73,925 in 1984. Apparent mortality was observed on 2,450 acres located in the northeast portion of La Junta Creek and in the Taos Pueblo River drainage.

Tres Piedras. Visible defoliation more than doubled from 1983 to the current outbreak level of 40,775 acres on the Tres Piedras entomological unit during 1984. Areas of defoliation extend from the Los Pinos drainage south to Tusas Box (figure 4).

El Rito. Defoliation on the El Rito entomological unit increased slightly from 43,850 acres in 1983 to 54,075 acres in 1984. Moderate to heavy defoliation was detected throughout most of the mixed conifer type in the El Rito drainage and on the west side of the Vallecitos drainage (figure 5).

Canjilon. Defoliation continued to increase on the Canjilon entomological unit from 2,150 acres in 1983 to 6,950 acres in 1984. Areas of defoliation were detected from Hidden Lake south to Faertes Spring, around Canjilon Lakes, and along Mogote Ridge (figure 6).

BIOLOGICAL INFORMATION

Egg mass surveys were conducted in August and early September 1984 to provide an indication of larval population densities and defoliation trends expected to occur in 1984. Branch samples were collected from a total of 628 trees from the following entomological units: Taos (141 trees); Questa (129 trees); Tres Piedras (343 trees); and El Rito (15 trees). Two branches (45 cm in length) were cut from opposite sides of the midcrown of three sample trees on each plot. Sample trees met the following criteria: Douglas-fir, dominant or codominant; 30 to 50 feet in height; relatively open grown with a full crown; and some budworm feeding evident, but the tree could not be severely defoliated or top-killed. Branches were bagged in ¼-bushel cloth bags, tied, labeled, and transported to the laboratory for examination. All bagged samples were stored in a walk-in cooler set at 40° F.

In the laboratory, the foliage was examined under ultraviolet light for budworm egg masses. Needles bearing egg masses were classed as from current year's foliage, or previous year's foliage, and kept separate in labeled pill boxes and later identified as new or old. All egg masses on current year's foliage were classed as new, and their characteristics formed the basis for aging egg masses found on previous year's foliage.

Egg mass density estimates from branch tips were averaged to present a mean for each entomological unit. Defoliation predictions for 1985 were determined from these estimates and the following information presented by McKnight et al. 1970:

Egg mass density[a]	Predicted defoliation class[b]
<1.55	Undetectable for all infestations
1.71 to 6.20	Undetectable for "static" infestations Light for "increasing" infestations
9.30 to 31	Light for "static" infestations Moderate for "increasing" infestations
>34.10	Moderate for "static" infestations Heavy for "increasing" infestations

[a] Number of egg masses per square meter of foliage.
[b] Defoliation class limits (percent of new growth).
Undetectable = <5 percent
Light = 5 to 35 percent
Moderate = 35 to 65 percent
Heavy = >65 percent

However, because of the extended duration of the current outbreak and the severity of defoliation which has already occurred on the CNF, egg mass density estimates may no longer correlate well with predicted defoliation class in areas heavily defoliated for five or more consecutive years. In these areas, even low budworm population levels could cause significant defoliation and bud damage.

RESULTS AND PREDICTION OF TREND

Egg mass survey results are presented and discussed by entomological unit and summarized in table 1.

Taos Entomological Unit. This unit includes the Taos Ranger District, Taos Pueblo lands, and adjoining private lands (figure 3). The egg mass density estimates for this unit remained near 1983 levels (1983--26.3, 1984--25.0 egg masses per meter^2 foliage). In the Rio Fernando de Taos drainage, egg mass densities averaged 33.6 ± 5.7 egg masses per meter^2 foliage. In the Rio Chiquito drainage, densities averaged 28.0 ± 7.6 egg masses per meter^2 of foliage.

These egg mass densities indicate defoliation will continue in the Taos entomological unit at moderate to possibly heavy levels in 1985. The Rio Chiquito drainage showed a substantial increase in egg mass densities, and defoliation can be expected to increase in this area.

Tree damages in the Rio Fernando de Taos drainage can be expected to worsen. Pockets of tree mortality and severe top-kill have occurred particularly along the north-facing slopes of this drainage. Tree mortality caused by other insect and disease problems, such as bark beetles, root disease, and dwarf mistletoe, will accelerate as a result of continued defoliation by the WSBW.

Questa Entomological Unit. This unit includes the Questa Ranger District and adjoining private lands (figure 1). Egg mass densities in this unit increased from 16.7 in 1983 to 38.5 egg mass per meter^2 foliage. Samples from the Red River Ski area averaged 19.5 ± 4.3 egg masses per meter^2 foliage. The upper Red River area, including Goose Creek and Bobcat Pass, had egg mass density estimates of 45.8 ± 4.4. Samples from the Rio Hondo drainage and the Cabresto Creek drainage had estimates of 38.7 ± 3.2 and 35.9 ± 6.5 egg masses per meter^2 of foliage, respectively.

Defoliation in this unit is expected to continue and possibly increase in severity during 1985. Tree damages caused by this defoliation can be expected to increase as well.

Stand conditions in the Red River area, particularly in lower Red River Canyon, exhibit severe defoliation, top-kill, and tree mortality resulting from the current budworm outbreak. A special survey utilizing color infrared photography was conducted in the Red River area to estimate current tree mortality. Results of this survey will be described in a separate report.

Tres Piedras Entomological Unit. This unit includes the Tres Piedras Ranger District, the northeast corner of the El Rito Ranger District from State Highway 110 east to Posos Lake (Kiowa Mountain and immediate surrounding area), and adjoining private lands (figure 4). WSBW infestations have been suppressed on various portions of this entomological unit on three separate occasions: In 1982 on 38,400 acres; in 1983 on 35,600 acres; and in 1984 on 34,600 acres. These efforts have achieved only limited success. Egg mass densities in 1984 ($\bar{x}$ = 14.7 ± 1.3) indicate budworm infestations will continue to be a problem throughout most of the host type on this unit in 1985. Egg mass data from areas sampled are briefly summarized below.

Areas sampled[3]	Egg masses/ meter^2	Areas sampled[4]	Egg masses/ meter^2
Kiowa Mtn.	6.8 ± 1.8 S.E.	Broke Off Mtn.	4.4 ± 2.0 S.E.
Maquinita	28.2 ± 6.5 S.E.	Cisneros Park	9.1 ± 2.0 S.E.
Biscara	3.8 ± 1.2 S.E.	Valle Grande	13.5 ± 5.7 S.E.
Tusas/Willow	29.3 ± 6.0 S.E.		
Duran Canyon	34.3 ± 7.8 S.E.		

[3]Areas were treated with a combination of carbaryl and Bacillus thuringiensis (B.t.) in 1982.
[4]Areas were treated with a combination of carbaryl and B.t. in 1983.

Areas sampled[5]	Egg masses/ meter^2
Alire Spring	17.4 ± 3.9 S.E.
Hopewell	14.6 ± 3.2 S.E.
Los Pinos	23.9 ± 6.9 S.E.
Olguin Mesa	15.0 ± 5.0 S.E.
Tio Grande	8.6 ± 2.3 S.E.
La Jara	8.9 ± 1.5 S.E.

Defoliation on this unit is expected to increase in both area and severity throughout the host type in 1985. Permanent tree damages, however, are not expected to occur for several more years.

El Rito Entomological Unit. This unit includes the El Rito Ranger District and adjoining private lands, excluding Kiowa Mountain and its adjacent private ownerships (figure 5). Egg mass densities on this unit decreased substantially from 42.6 in 1983 to 20.8 ± 4.1 egg masses per meter^2 of foliage 1984. Egg mass samples on this unit were primarily collected from the middle and south forks of the Canada del Agua drainage.

These egg mass densities indicate budworm defoliation will continue to occur at moderate to heavy levels on this unit in 1985. Defoliation to the mixed conifer host type will continue to be heaviest along and north of Canada del Borracho.

Valle Vidal and Canjilon Entomological Units. Although no egg mass data were collected from these entomological units in 1984, defoliation resulting from the budworm on these units is expected to continue and possibly increase in severity in 1985.

MANAGEMENT ALTERNATIVES

Management alternatives available to forest managers for the current WSBW outbreaks consist of primarily two courses of action: (1) No action or (2) suppression with one or a combination of registered pesticides. A discussion of these management objectives follow.

[5]Areas were treated with B.t in 1984.

No Action. With this approach, the outbreak would be allowed to run its course until a population collapse occurred from a combination of: (a) A lack of foliage to maintain a larval population; (b) unfavorable weather conditions; (c) heavy predation and parasitism; and (d) a microbial epizootic. Adverse and beneficial effects of the outbreak would have to be accepted. These are:

1. This alternative would not be effective in preventing additional tree damages. Impacts to resource values and uses caused by the budworm would have to be accepted under this alternative. Although damages resulting from the WSBW in the Southwest are not completely known, the following are the best available estimates.

Tree damages	Maximum damages (percent)
Growth loss	30
Understory mortality	25
Sawtimber mortality	5
Top-killing	25
Cone crop reduction	90+
Christmas tree quality loss	90+

2. The costs of this alternative can be considered as the value of the resource damaged. Also, the depletion of the understory could necessitate the expenditure of funds for reforestation.

3. Visual quality and economic and social impacts would continue if this alternative were selected.

Direct Suppression. Suppression tactics can be used against the current infestation. These tactics involve the aerial application of insecticides on (1) the entire infestation, (2) selected entomological units, or (3) high-value stands or groups of stands with the intent of reducing budworm populations and related tree damages. Individual high-value tree protection can be achieved with insecticide applications from the ground.

Aerial applications of insecticides are short-term budworm management techniques, at best, suppressing budworm populations for 5 years and possibly preventing serious tree damages for an additional 3 to 5 years (Telfer 1983). Insecticide applications are most efficacious when applied to low-density budworm populations (<20 larvae per 100 buds) over an entire infestation or entomological units. At higher budworm population densities or where infestations and entomological units are only partially treated, insecticide applications are less effective. When insecticide applications are targeted at limited areas (stands, scenic corridors, or recreation areas) with high density budworm populations (<20 larvae per 100 buds), annual applications will be necessary to achieve treatment benefits.

Applications must be carefully timed to larval development and bud flush; i. e., when 20 percent of the larvae are in the fifth and sixth instars and buds are 85 to 90 percent flushed. This would insure

maximum effectiveness with a minimum dosage of insecticide. An application of this type is designed to utilize indigenous natural control agents to further reduce and maintain the budworm population at a low level.

Effects of this alternative are:

1. A direct suppression program can reduce tree damages and losses, thus protecting resource values.

2. A direct suppression program will cost $7 to $12 per acre each treatment year dependent upon the program size, application strategy, and insecticides used.

3. Proper use of insecticides will not pose a significant hazard to humans, wildlife, or the environment.

Insecticides registered for use against the budworm follow:

1. Carbaryl (carbamate insecticide). The Sevin 4 oil formulation of carbaryl has given consistently satisfactory results in suppressing budworm outbreaks throughout the West. An outbreak on the Santa Fe National Forest, New Mexico, was successfully suppressed in 1977, and the outbreak has remained at a low level for 5 years (Telfer, Ragenovich, and Rogers 1982). Carbaryl is a nonpersistent pesticide which is available for general use. One pound of active ingredient per acre is the registered dosage rate, and no lasting environmental effects have been identified at this application rate.

2. Acephate (organophosphate insecticide). Orthene is a nonpersistent insecticide registered for use against the WSBW and other forest defoliators. Although this insecticide has been shown to be effective against the budworm, it has never been used in the Southwest against the WSBW.

3. Mexacarbate (carbamate insecticide). Mexacarbate (Zectran) is a nonpersistent pesticide which is available for use against the WSBW. Mexacarbate is applied at a rate of 0.15 pounds of active ingredient per acre. No lasting environmental effects have been identified when properly applied at this rate. For use in the Southwest, mexacarbate requires additional pilot testing before it can be recommended for operational use.

4. Microbial Insecticides. Bacillus thuringiensis (B.t.), a bacterium, has been used experimentally and operationally in the Southwest. B.t. has adequately reduced WSBW populations, although results are sometimes inconsistent. Continued improvements of B.t. formulations has shown promise in increasing the insecticide's efficacy.

RECOMMENDATIONS

Management of the Current Western Spruce Budworm Outbreak. Within the Taos, Questa, and El Rito entomological units, we recommend direct suppression in 1985 for high use, developed recreational areas (campgrounds, ski areas, etc.) where visual quality or esthetics are a major management concern. Aerial applications of B.t. are recommended for the majority of these areas where appropriate. In smaller site-specific areas (campgrounds, etc.) where high value, individual trees must be protected from further defoliation and deterioration and where aerial applications of B.t. may not be suitable, ground applications using acephate (Orthene) or carbaryl (Sevin) are recommended. If areas to be treated are located in flood-plain situations or near aquatic ecosystems, we recommend ground applications of acephate (Orthene) to be carefully applied to designated trees requiring protection. Specific areas to be treated should be evaluated on an individual basis to determine whether or not treatments will be biologically effective.

Regardless of the method of application, suppressions tactics should be targeted at high-risk stands and/or areas; those stands or areas with a high percentage of Douglas-fir and white fir species mix. Direct suppression will minimize further stand deterioration and possibly improve the visual quality in already infested stands. To be effective, however, treatments may have to be conducted annually until the current outbreak collapses.

Our recent suppression efforts on the Tres Piedras entomological unit appear to have achieved limited, short-term (1 to 2 years) effectiveness. Portions of the entomological unit were treated over three consecutive years (1982-84). This limited effectiveness is attributed to higher than expected WSBW population densities, the inability to initially treat the entire infestation within the entomological unit, and poor weather conditions which occurred subsequent to treatment on certain spray blocks. Thus, budworm management objectives for this unit need reevaluation. Any reevaluation should closely consider timber management objectives and potential budworm impacts, including the economics of various management strategies. Biologically, large-scale direct suppression efforts against the budworm have only a marginal chance of success at this time on the Tres Piedras entomological unit. However, should high-value stands exist within this unit, targeted insecticide treatments to these stands to maintain or protect stand values are possible. High-value stands can be defined not only as important visual corridors or developed recreational areas, but stands critical to timber management objectives where positive economic benefits of insecticide treatments are easily demonstrated. This strategy may necessitate periodic re-treatments, depending upon the severity and duration of the current western spruce budworm outbreak.

Management of Mixed Conifer Stands to Prevent and/or Minimize Impacts of Future WSBW Outbreaks. The WSBW should be considered a long-term forest management problem, and addressed through long-range forest

planning. The recommended management approach is silvicultural strategies which reduce stand susceptibility/vulnerability. Specifically, silvicultural prescriptions should stress "state-of-the-art" stand management. These strategies should include, but are not limited to: (1) Intermediate cuttings, such as commerical or precommerical thinning and sanitation/salvage, to increase stand vigor, regulate stocking, and favor nonhost tree species; (2) regeneration cuttings using the clearcut and shelterwood methods designed to create a mosaic of more even-aged stands, with a lower percentage of true fir; and (3) artifical regeneration with nonhost tree speices.

In addition to silvicultural management approaches, high-value esthetic and recreation areas, where budworm damages would substantially impair these resource values, should be identified. Threshold damage levels should be developed for these areas. Should budworm damage enter these threshold levels, suppression strategies should be planned and implemented to prevent further deterioration.

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TABLE 1.--Summary of the egg mass and aerial detection surveys on the Taos, Questa, Tres Piedras, and El Rito entomological units

Taos entomological unit		1976	1977	1978	1979	1980	1981	1982	1983	1984
New egg masses/ square m foliage		38.3	22.3	36.3	42.8	50.6	14.1	17.2	26.3	25.0
Egg mass density ratio[a]		1.7:1	0.6:1	1.6:1	1.2:1	1.2:1	0.3:1	1.2:1	1.5:1	0.9:1
Actual defoliation[b] (acres)	L	9,400	15,040	2,725	6,477	31,200	6,375	7,175	18,500	15,625
	M	6,600	10,800	2,790	9,191	26,750	41,125	18,550	6,825	26,550
	H	560	0	4,250	282	6,975	15,775	3,375	50	31,750
	TOTAL	16,560	25,840	9,765	15,950	64,925	63,275	29,100	25,375	73,925
Questa entomological unit										
New egg masses/ square m foliage			9.9	17.9	43.1	47.6	31.3	26.3	16.7	38.5
Egg mass density ratio[a]			3.4:1	1.7:1	2.4:1	1.1:1	0.7:1	0.8:1	0.6:1	2.3:1
Actual defoliation[b] (acres)	L	1,900	13,080	2,560	3,174	22,850	4,800	2,025	7,625	625
	M	300	960	2,330	5,197	15,550	39,700	8,550	1,975	17,750
	H	0	320	384	6,221	3,275	18,550	36,400	175	34,325
	TOTAL	2,200	14,360	5,274	14,592	41,675	63,050	46,975	9,825	52,700

TABLE 1.--Summary of the egg mass and aerial detection surveys on the Taos, Questa, Tres Piedras, and El Rito entomological units--Continued

Tres Piedras entomological unit		1980[c]	1981[d]	1982	1983	1984
New egg masses/ square m foliage		1.8	35.0	6.8	22.3	14.7
Egg mass density ratio[a]			19.4:1	0.2:1	3.3:1	0.6:1
Actual defoliation[b] (acres)	L	550	5,650	2,625	8,800	14,525
	M	0	50	1,725	9,650	25,725
	H	0	0	0	50	525
TOTAL		550	5,700	4,350	18,500	40,775
El Rito entomological unit						
New egg masses/ square m foliage		29.7	33.5	18.6	42.6	20.8
Egg mass density ratio[a]			1.1:1	0.5:1	2.3:1	0.5:1
Actual defoliation[b] (acres)	L	325	1,700	20,275	7,225	3,925
	M	900	1,100	13,075	35,350	26,400
	H	75	200	600	1,275	23,750
TOTAL		1,300	3,000	33,950	43,850	54,075

[a] Egg mass density ratio is the ratio of new egg masses in the survey year to new egg masses of the previous year.
[b] Actural defoliation as determined from aerial detection survey; L = light, M = moderate, H = heavy.
[c] Data obtained from report R-3 81-4.
[d] Data previously combined under Tres Piedras entomological unit in 1981.

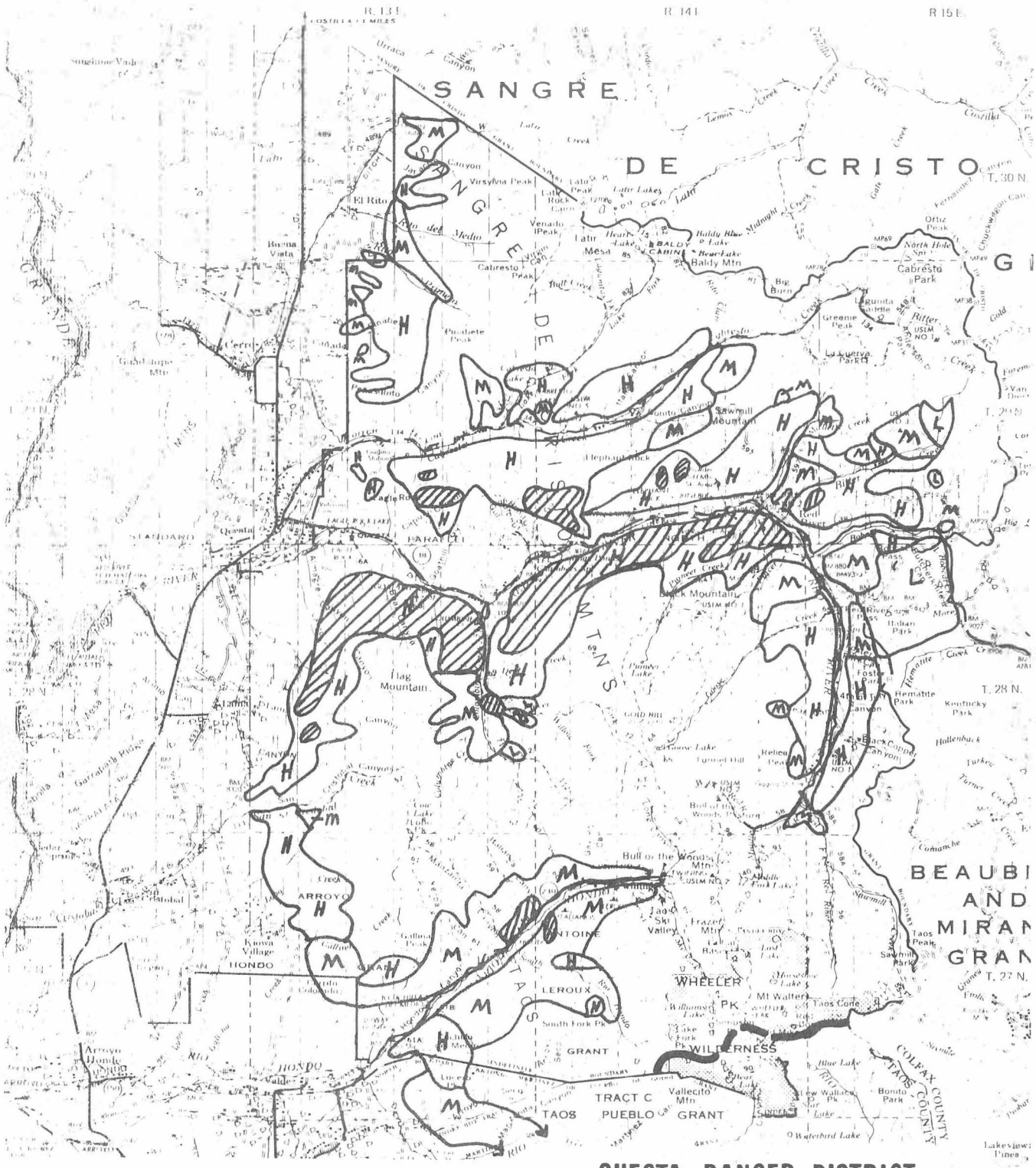

FIGURE 1.--Extent of western spruce budworm defoliation and mortality on the Questa entomological unit, 1984

L = Light; M = Moderate; H = Heavy

Apparent mortality -

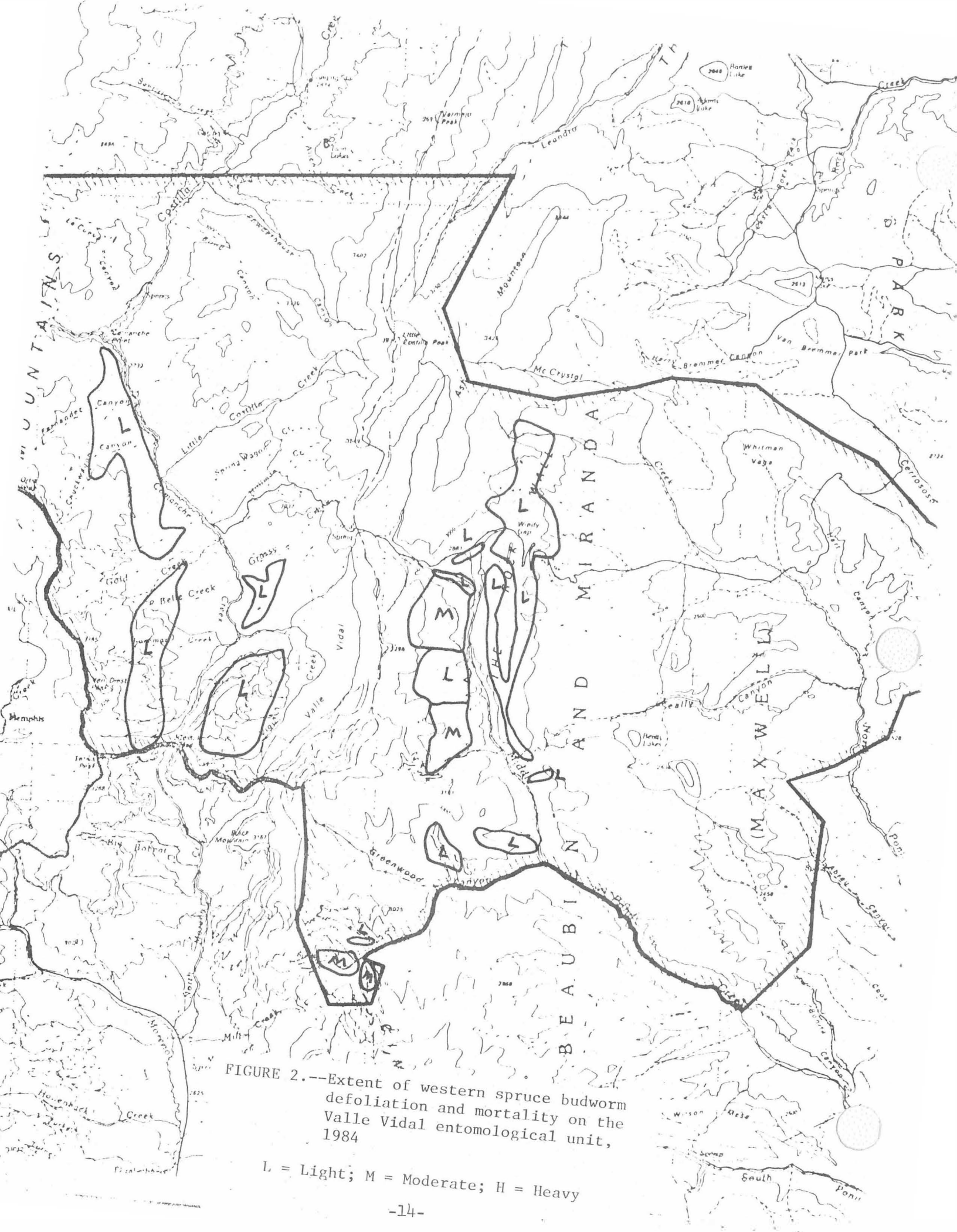

FIGURE 2.--Extent of western spruce budworm defoliation and mortality on the Valle Vidal entomological unit, 1984

L = Light; M = Moderate; H = Heavy

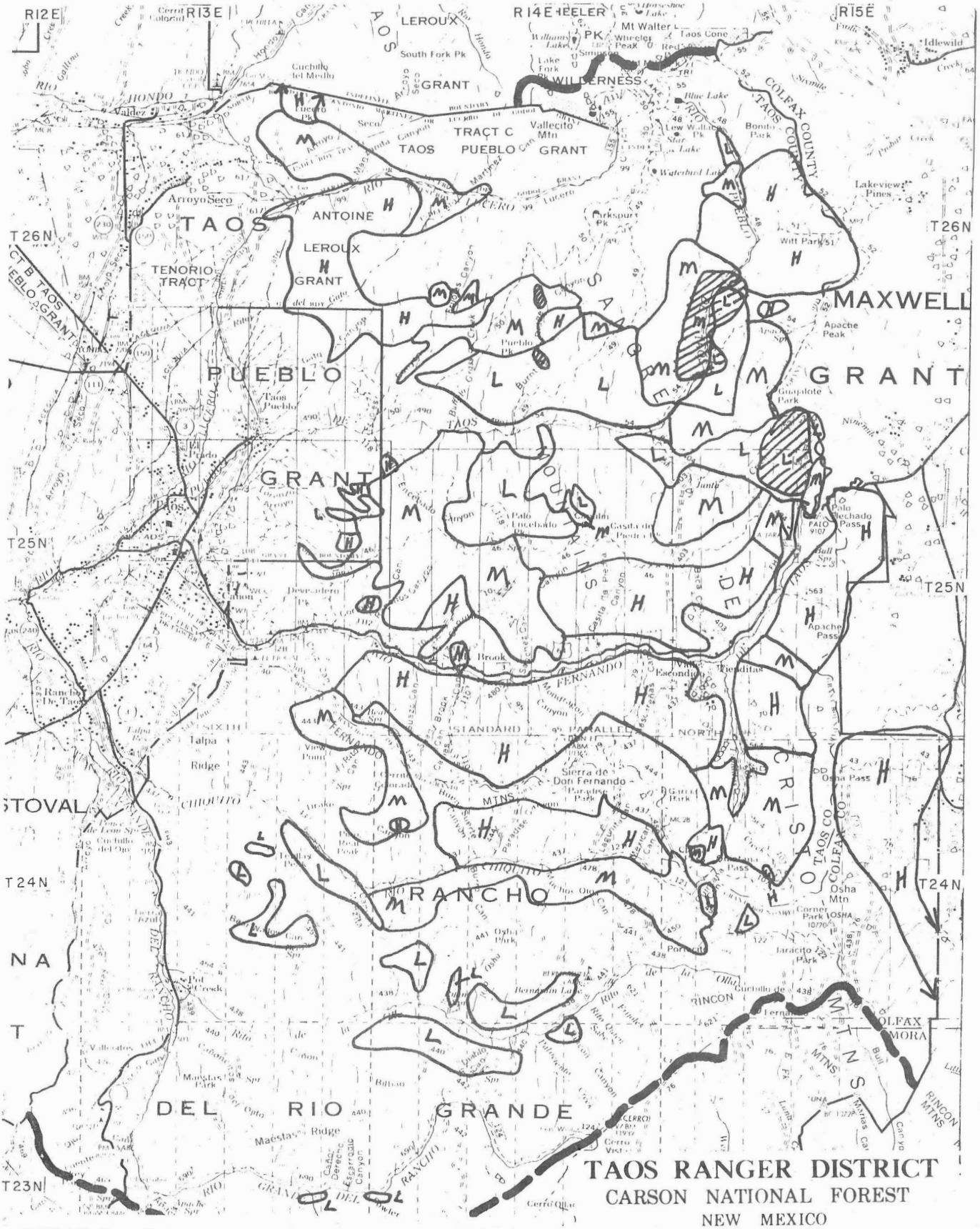

FIGURE 3.--Extent of western spruce budworm defoliation on the Taos entomological unit, 1984

L = Light; M = Moderate; H = Heavy

Apparent mortality -

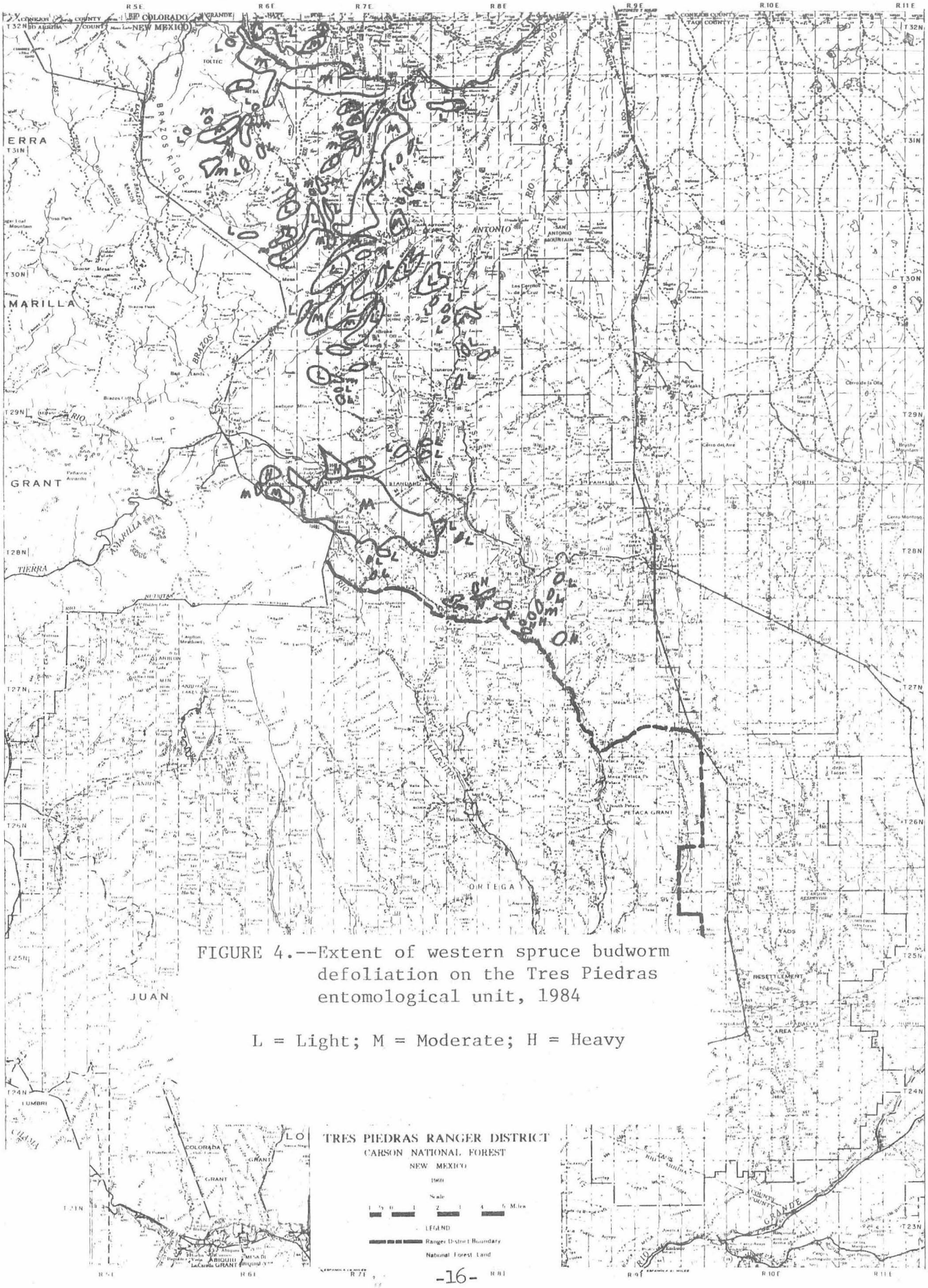

FIGURE 4.--Extent of western spruce budworm defoliation on the Tres Piedras entomological unit, 1984

L = Light; M = Moderate; H = Heavy

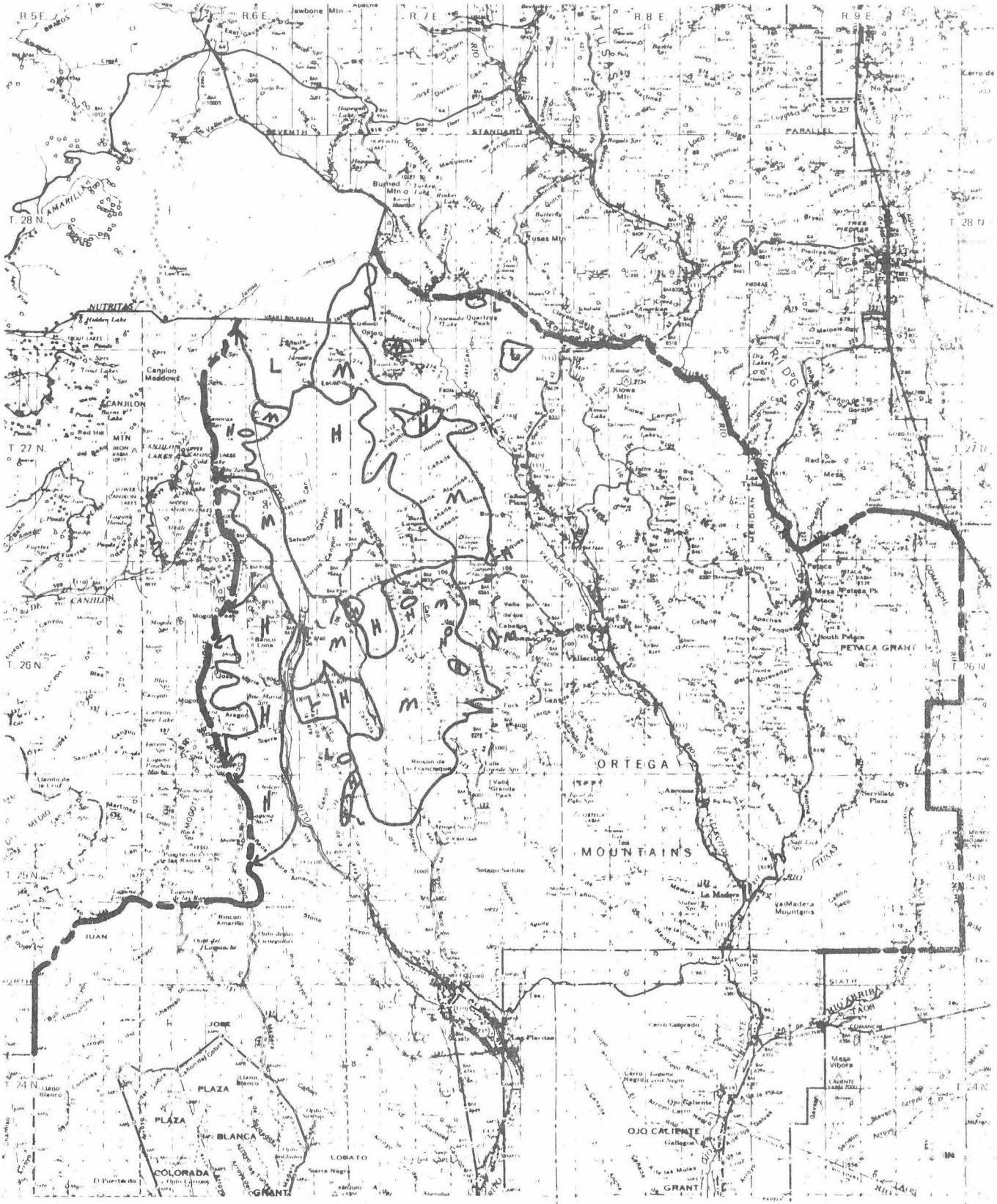

FIGURE 5.--Extent of western spruce budworm defoliation on the El Rito entomological unit, 1984

L = Light; M = Moderate; H = Heavy

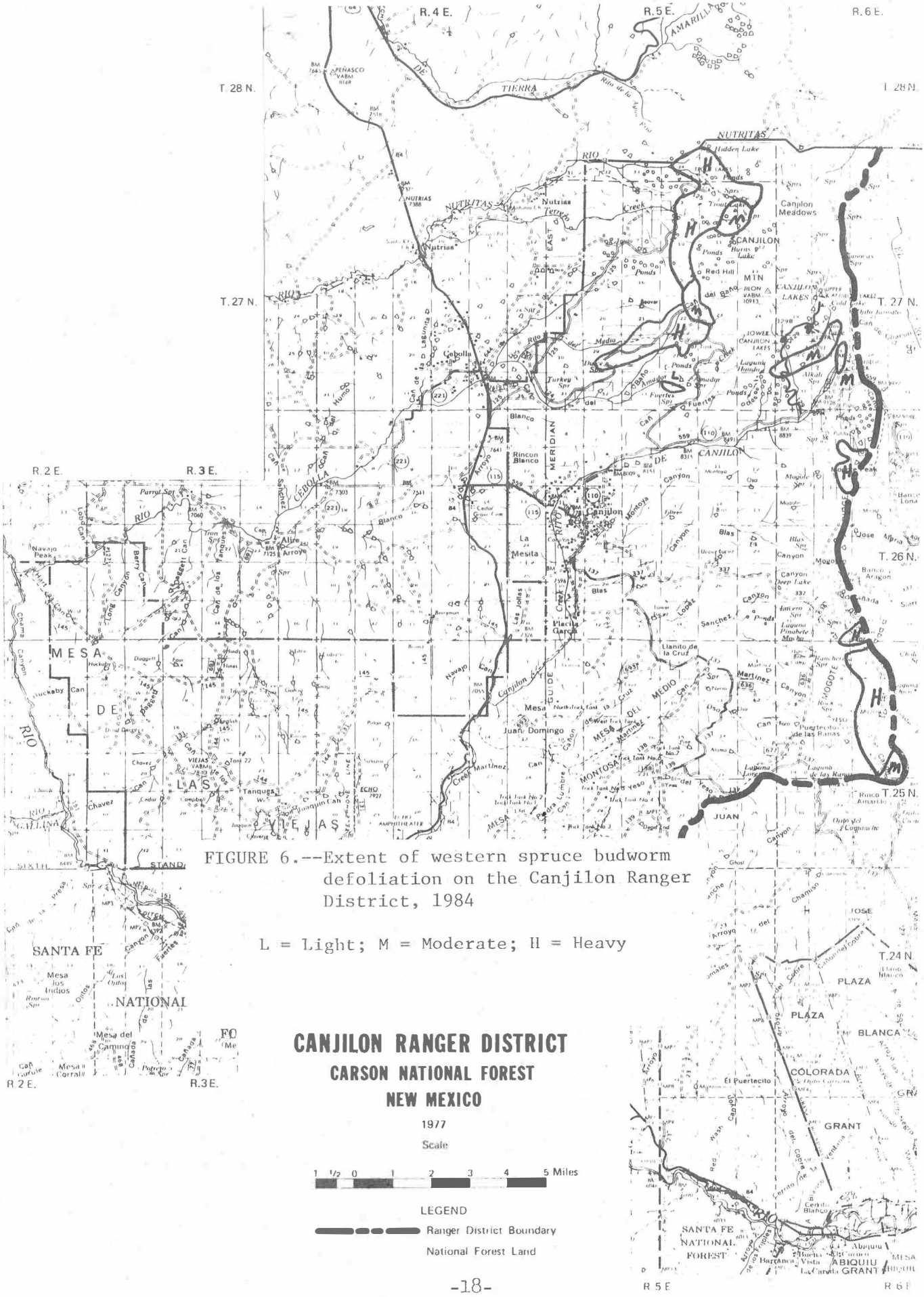

FIGURE 6.--Extent of western spruce budworm defoliation on the Canjilon Ranger District, 1984

L = Light; M = Moderate; H = Heavy